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COMMON CONTROL CHANNEL DESIGN FOR COGNITIVE RADIO AD HOC NETWORK USING OFDM

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ABSTRACT

In wireless communication, the important factor is to face its spectrum scarcity; to solve that scenario we are going to use the spectrum opportunistically. The Cognitive radio (CR) technology is defined to solve the problems in wireless networks resulting from the limited available spectrum and the inefficiency in the spectrum usage by sharing the existing wireless spectrum opportunistically. In CRAHN to facilitate these tasks, an always-on, out-of-band common control channel (CCC) design is proposed that uses non -contiguous OFDM subcarriers placed within the dynamic guard bands separating the channels of the licensed spectrum for efficient spectrum utilization. This proposed CCC design is to ensure the spectrum sharing, network connectivity, efficient data rate of CR users and dynamic guard bands when compared to cluster based and sequence based CCC design.

KEYWORDS: Cognitive Radio, CRAHN, Common Control Channel, OFDM

INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is the modulation technique for European standards. OFDM is a type of multichannel modulation that divides a given channel into many parallel sub channels or subcarriers, so that multiple symbols are sent in parallel. A wireless ad-hoc network is number of nodes that forward data packets in a decentralized manner over multiple hops to the destination. The increasing deployment of such networks have led to a growing congestion and spectrum scarcity in the unlicensed 2.4GHz ISM band.

The recent advancements in radio hardware and changes in the spectrum regulation policy of the Federal Communications Commission (FCC) have allowed the opportunistic use of portions of the licensed spectrum by unlicensed users. Cognitive radio (CR) is envisaged as the key enabling technology that allows the CR users to detect the spectrum availability, share the spectrum resource, and adapt to changes in its availability, so that the licensed or primary users (PUs) are unaffected. Specifically, in CR ad hoc networks, nodes must undertake these spectrum related functions in the absence of a central controller, and also maintain end-to-end coordination spanning multiple hops. In such cases, the coordination must occur over a common control channel (CCC) that is not interrupted by the changing PU activity, thereby ensuring a continuously available connection between the CR devices[1]. Cognitive radio networks (CRN) have attracted great attention recently as a means to resolve the critical spectrum shortage problem. The need for a CCC is evident in the four main functions of a CR network, namely, spectrum sensing, sharing, decision, and mobility, each of which involves extensive control messaging. In all these cases, the reliable delivery of the control messages is a key factor in ensuring the smooth operation of the protocols. As the transmission and reception of these control messages must not be impaired, we believe that the CCC must be always-on, even under the fluctuating spectrum availability.

Literature Survey

As shown in Figure 1 the current control channel design approaches can be classified into three functional groups: Cluster-based, sequence-based and dedicated CCC [1]. Additionally, the control channel designs can be further categorized into local and global coverage, depending on the extent of the physical region that the CCC covers.

In cluster-Based CCC a number of CR users form clusters, and a common CCC is chosen for all of them. This grouping of nodes may be based on their physical proximity, spectrum usage conditions, and other common environmental factors.

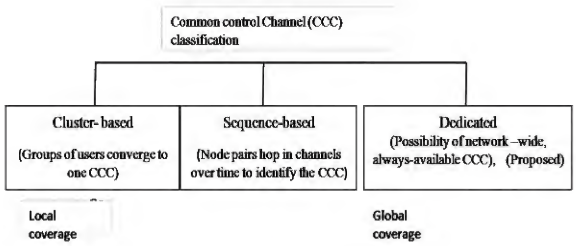

Figure 1: Common Control Channel Design Classification

In Sequence-Based CCC the CR users tune themselves to the PU channels in a pseudorandom or pre decided sequence, till they arrive at a common channel with the neighbours.

In dedicated CCC the data and control signalling are separate; hence more than one transceiver can be used. The CR users form the cluster but it has individual channel for data transmission and control information. local and global coverage. It minimizes the CCC disruptions caused by PU activity.

Several recent works in MAC protocols for CR networks assume the presence of a dedicated CCC that is assigned to all the users. Though these works do not specifically describe the design of such control channel, there is a clear motivation to provide an always available and network wide CCC that could be used for broadcast messaging. Such an always available CCC is more efficient in spectrum utilization, as opposed to the sequence based design, which needs a prolonged synchronization time during the channel hopping. Moreover, unlike cluster based approaches, a network-wide CCC has lower coordination overhead between groups of CR users. This also allows for scalability, and does not need maintaining specialized network topologies for the CCC operation.

The channel for the dedicated CCC must be carefully chosen, so that it is not interrupted over long periods of time. The main difficulty is identifying a uniformly acceptable channel throughout the entire network. Moreover, care should be taken to ensure that the CCC does not lower the spectrum utilization efficiency in low-traffic scenarios, as spectrum for the control messaging is exclusively reserved.

Proposed Model

This paper proposes the use of the guard bands between the channels of the licensed spectrum for an out-of band CCC. The comparatively small portions of the frequency space contained in the guard bands serve as buffers between two adjacent PU channels. In this approach, a limited number of Orthogonal Frequency-Division Multiplexing (OFDM) subcarriers are inserted in each guard band [2]. The CR users may decide in a distributed manner which of these subcarriers is active at a given time, and these active subcarriers, considered together, compose the CCC. Figure 2 shows our proposed CCC design with the guard bands G1 _ G3 between the PU channels C1 _ C3, respectively.

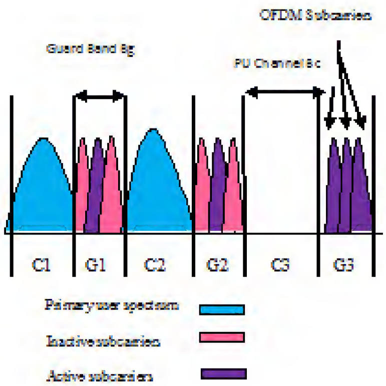

Figure 2: CCC Operation using Guard Bands in the Licensed Spectrum

The guard bands of bandwidth Bg are smaller than the PU channels of bandwidth Bc, and have three OFDM subcarriers each. The active subcarriers are indicated as filled. In OFDM, the data stream from the sender is divided among several subcarriers. The more the number of subcarriers, the greater is the effective rate of the CCC. Our proposed CCC design is composed of two stages, called as the 1) OFDM subcarrier allocation stage, and the 2) CCC operation stage, respectively [2]. The first stage of deciding the OFDM-specific subcarrier parameters is done before the network initialization. Specifically, a feasibility framework is devised that allows the selection of the OFDM subcarrier bandwidth, the maximum number of subcarriers per guard band, symbol preamble time, and the transmit power. However, not all the allowed subcarriers may be active at the same time. The choice of the active guard bands (and hence, the subcarriers) is done in the second stage, once the CR network begins operation.

OFDM-Based Feasibility Framework for Subcarrier Allocation

In this stage, the OFDM subcarrier parameters are designed based on the channel structure of the licensed spectrum. This design process is composed of the following two steps:

- The entire licensed spectrum is considered as a contiguous set of OFDM subcarriers. First, all the subcarriers overlapping with the primary channels are rendered inactive, as they cannot be used in our always-on CCC. As an example, the subcarriers that overlap with channels C1, C2, and C3 in Figure 2, are made inactive.
- For the remaining subcarriers in the different guard bands (G1, G2, and G3 in Figure 2), we formulate a feasibility problem that aims to find the subcarrier bandwidth (hence, their number), OFDM preamble time, and transmit power, so that the PU network is protected, the CR CCC data rate is maximized, the network connectivity is maintained, and hardware or OFDM-specific constraints are met.

The general OFDM transmitter model is as follows:

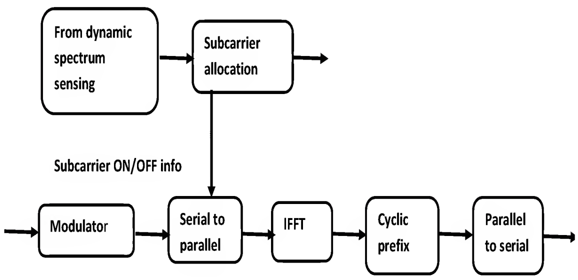

Figure 3: OFDM Transmitter Stage

The modulator is used for converting the bits into samples and modulating the signals. Phase shift keying PSK modulation is mostly used. Since OFDM is parallel communication, serial to parallel converter(S/P) is used at transmitter section. Inverse Fourier transform (IFFT) has been carried for converting time to frequency domain. Cyclic prefix (CP) is addition of bits in data. One difficulty is that channel dispersion destroys the orthogonality between subcarriers and causes inter carrier interference (ICI). In addition, a system may transmit multiple OFDM symbols in a series so that a dispersive channel causes inter symbol interference (ISI) between successive OFDM symbols. The insertion of a silent guard period between successive OFDM symbols would avoid ISI in a dispersive environment but it does not avoid the loss of the subcarrier orthogonality. If N sub-carriers are used, and each sub-carrier is modulated using M alternative symbols, the OFDM symbol alphabet consists of M^N combined symbols. The low-pass equivalent OFDM signal is expressed as $v(t) = \sum_{k=0}^{N-1} Xk\ e^{j2\pi kt/T}, 0 \le t < T$

where$\{X_k\}$are the data symbols, N is the number of sub-carriers, and T is the OFDM symbol time. The sub-carrier spacing of 1/T makes them orthogonal over each symbol period; this property is expressed as:

$$1/T \int_0^1 (e^{\frac{j2\pi k1t}{T}}) * (e^{\frac{j2\pi k2t}{T}})dt$$

$$= 1/T \int_0^T (e^{\frac{j2\pi(k2-K1)t}{T}})dt$$

$$= \delta k1k2$$

Where (.)* denotes the complex conjugate operator and ∂ is the Kronecker delta To avoid inter symbol interference in multipath fading channels, a guard interval of length T_g is inserted prior to the OFDM block. During this interval, a *cyclic prefix* is transmitted such that the signal in the interval $-T_g \le t \le 0$ equals the signal in the interval $(T-T_g) \le t \le T$. The OFDM signal with cyclic prefix is thus $v(t) = \sum_{k=0}^{N-1} Xk\ e^{j2\pi kt/T}, -Tg \le t < T$

CCC Operation

In OFDM, the data stream from the sender is divided among several subcarriers. Each subcarrier is assigned to different users for particular applications, since it has different frequencies. Here, the applications such as TV, CDMA, and Web TV will be assigned. The data transmission from sender to TV users is higher than other users. The guard bands designed is fixed in size. The more the number of subcarriers, the greater is the data rate of the CCC, which is obtained. Dedicated always on CCC is always available is more efficient in spectrum utilization. Also, CR users have a reliable channel for exchanging spectrum information. A different set of subcarrier is rendered active, so that possible interference related adverse effects on the PU performance are reduced.

CCC CRAHN Model

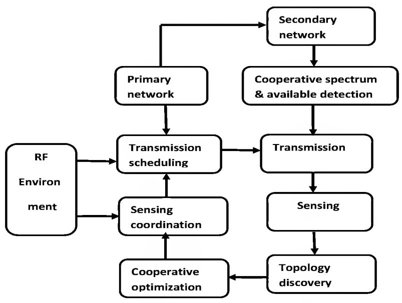

Figure 4: CCC CRAHN Model

The primary network is an existing network where primary users (PU) have a license to operate in a certain spectrum band. Due to their priority in spectrum access, the PUs should not be affected by unlicensed users. For that reason, dedicated common control channel is provided to send control information about PU activity to CR users. The secondary networks refer to CR users. In a CRAHN's, Cooperation Optimization is used for CR users to send their sensing information over the channel through multiple access techniques, and thus, their individual traffic adds to the probability of packet collisions. By requesting the sensing information from several CR users, the user that initiates the cooperative sensing improves the accuracy but also increases the network traffic. Sensing Coordination is used to co-ordinate the CR user to entire network depending upon the nature of the sensing. Transmission Scheduling is used for choosing the transmission time and duration, CR users may be able to share spectrum that is currently being used by a PU, without affecting the performance of the latter

RESULTS

Primary users are using the spectrum and transmitting the packet

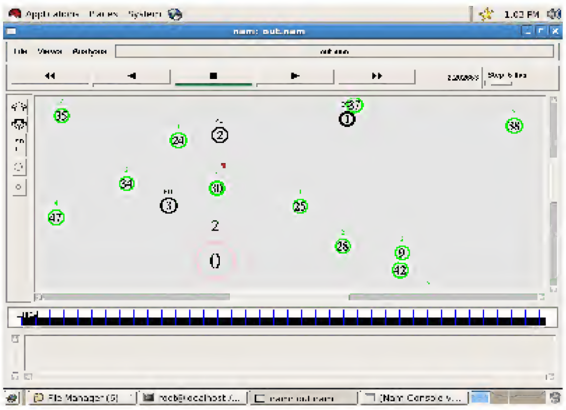

Figure 5

Secondary nodes (crahn users) sensing the licensed spectrum

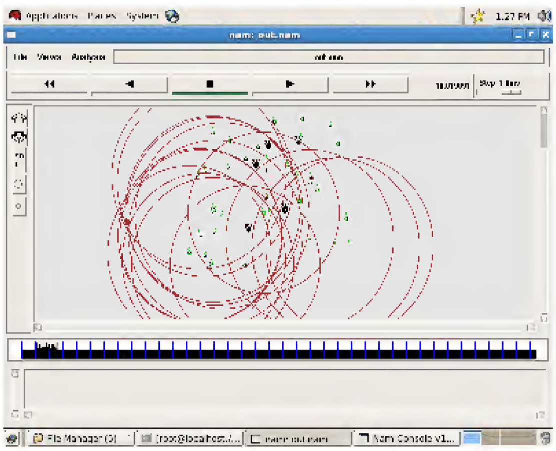

Figure 6

Different crahn users sending the data simultaneously

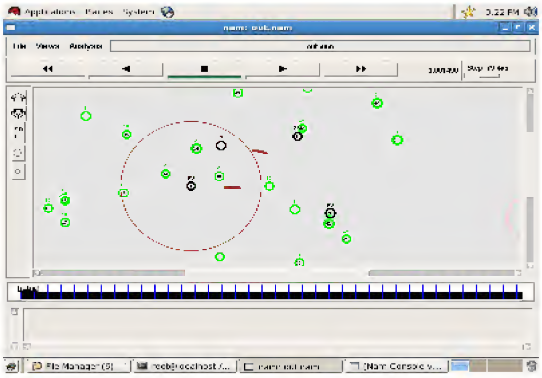

Figure 7

No of CR users Vs allocation band

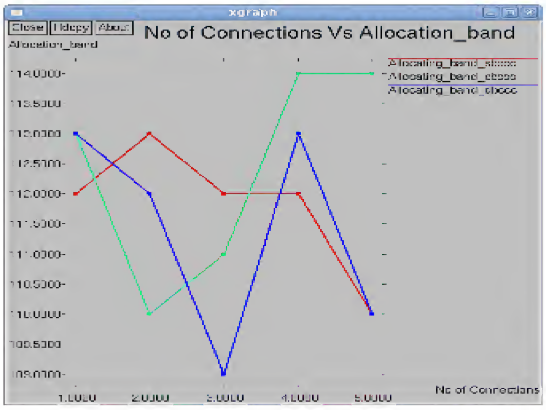

Figure 8

CONCLUSIONS

CR is an exciting and promising technology that offers a solution to the spectrum crowding problem. By employing OFDM transmission in CR systems; adaptive, aware and flexible systems that can interoperate with current technologies can be realized. An efficient CCC is a prerequisite for the higher layer protocols by enabling the sharing of local spectrum information, and facilitates cooperation in the CR network. This area is still in a nascent stage, and further work may proceed along the lines of increasing the data rate for the CCC, and improved learning algorithms that allow a fast convergence on the suitable set of the guard bands.

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